INVENTORY STUDY PLAN FOR VASCULAR PLANTS AND VERTEBRATES:

NORTHERN COLORADO PLATEAU NETWORK NATIONAL PARK SERVICE

September 30, 2000

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I. INTRODUCTION AND OBJECTIVES OF BIOLOGICAL INVENTORY

The overall mission of the National Park Service is to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations (National Park Service 1988). Actual management of national parks throughout the Service's history has emphasized public use and enjoyment, often to the detriment of natural ecosystems within the parks (National Research Council 1992; Sellars 1997). Funding and support for science and natural resource management has been lacking or severely limited throughout much of the 80+ year history of the Park Service. As a result, basic biological inventories of park ecosystems have not been completed for most parks in the national system (Stohlgren 1995). An understanding of what species occur within a park, as well as information on their current status, distribution and condition is essential to making informed management decisions concerning park natural resources.

The lack of and need for park based biological information has long been recognized (Sellars 1997). In response to this need the National Park Service initiated an Inventory and Monitoring Program in the early 1990's to conduct scientific research and study long-term changes of biological resources in national parks (National Park Service 1992). This program largely emphasized work in 'prototype' parks that served as models for other parks in the system. By the late 1990's most parks still lacked basic biological inventories. In 1998, Congress appropriated servicewide funding for a "program of inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the conditions of National Park System resources" (National Park Service 1999a). As part of this new program 32 networks of parks nationwide have been asked to develop detailed study plans for biological inventory. The study plan which follows is for the Northern Colorado Plateau Network.

The *Northern Colorado Plateau Network* (NCPN) encompasses a total of 16 units managed by the National Park Service in Utah, western Colorado and southwestern Wyoming (Figure 1; Table 1). In addition to individual park offices, the Southeast Utah Group (SEUG) office in Moab is a combined administrative unit for four nearby parks (ARCH, CANY, NABR and HOVE). Within or adjacent to the NCPN are collaborative offices of the U.S. Geological Survey – Biological Resources Division (Table 1). USGS scientists at these locations have been instrumental in helping the NCPN develop this study plan. The new Cooperative Ecosystem Study Unit (CESU) in Flagstaff is also a key collaborator in this effort. A nine-member steering committee comprised of park resource staff has been appointed to oversee development of the inventory and monitoring program for the Northern Colorado Plateau Network. The network has hired a full-time inventory and monitoring program coordinator and two biotechs to assist in program development. This staff will be expanded in the coming year as the NCPN initiates the monitoring phase of the program.

Parks within the network are widely scattered within four western states and range in size from 16 to 136,611 hectares (40 to 337,570 acres) (Table 1). Most parks in the network are adjacent to other federal lands managed by the USDA Forest Service and USDI Bureau of Land Management. Parks within the network have established relationships with these federal agencies, as well as state agencies, academic institutions and other organizations. Since individual parks are typically small islands embedded within larger landscapes it is important that the Park Service collaborate with partners beyond park boundaries, especially in choosing and applying inventory protocols and in data sharing. The NCPN is working closely with the Southern Colorado Plateau Network to ensure that taxonomic group protocols are comparable across parks in the two networks.

Figure 1.

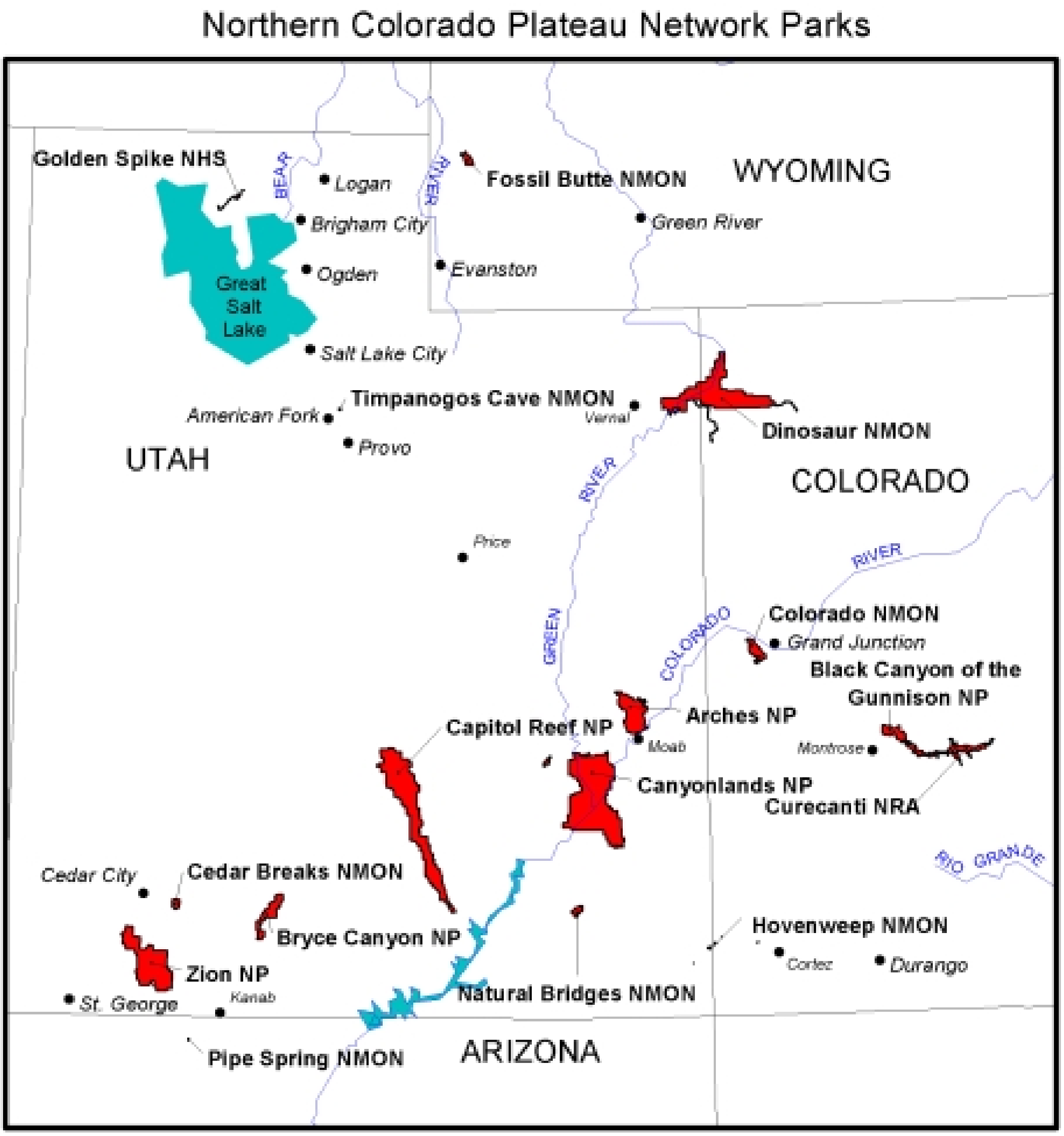
Northern Colorado Plateau Network Parks
Golden Spike NHS
BEAR
Logan
RIVER
Fossil Butte NMON
WYOMING
Brigham City
Green River
Ogden
Evanston
Great Salt Lake
Salt Lake City
Timpanogos Cave NMON
American Fork
Vernal
Dinosaur NMON
Provo
UTAH
COLORADO
RIVER
Price
RIVER
GREEN
COLORADO
Colorado NMON
Grand Junction
Black Canyon of the Gunnison NP
Capitol Reef NP
Arches NP
Moab
Montrose
Canyonlands NP
Curecanti NRA
RIO GRANDE
Cedar City
Cedar Breaks NMON
Bryce Canyon NP
Hovenweep NMON
Cortez
Durango
Zion NP
Natural Bridges NMON
St. George
Kanab
Pipe Spring NMON
ARIZONA

Table 1. National Park Service Units and collaborative offices in the Northern Colorado Plateau Network

Unit	Parkcode	Hectares	Acres
Arches National Park	ARCH	30,979	76,519
Black Canyon of the Gunnison National Park	BLCA	12,660	30,300
Bryce Canyon National Park	BRCA	14,508	35,835
Canyonlands National Park	CANY	136,587	337,570
Capitol Reef National Park	CARE	97,936	241,904
Cedar Breaks National Monument	CEBR	2,491	6,154
Colorado National Monument	COLM	8,280	20,453
Curecanti National Recreation Area	CURE	16,390	40,500
Dinosaur National Monument	DINO	85,361	210,844
Fossil Butte National Monument	FOBU	3,319	8,198
Golden Spike National Historic Site	GOSP	1,107	2,735
Hovenweep National Monument	HOVE	318	785
Natural Bridges National Monument	NABR	3,010	7,626
Pipe Spring National Monument	PISP	16	40
Timpanogos Cave National Monument	TICA	101	250
Zion National Park	ZION	59,947	146,560
Southeast Utah Group Office, National Park Service, Moab	SEUG		
Colorado Plateau Cooperative Ecosystems Study Unit, Flagstaff	CESU		
Canyonlands Field Station, US Geological Survey, Moab			
Colorado Plateau Field Station, US Geological Survey, Flagstaff			
US Geological Survey, Albuquerque			

This project focuses on completing basic inventories of vascular plants and vertebrate animals for parks within the Northern Colorado Plateau Network. A primary goal of the inventory project is to provide park managers in the network with scientifically sound information on the nature and status of selected biological resources in a readily accessible form to assist on-the-ground resource management. Organization of a network based inventory and monitoring program offers several benefits through increased efficiencies in designing and conducting inventory work, and improved opportunities for exchange of ideas and information across parks.

The objectives of this inventory project are as follows:

1. To document through existing, verifiable data and targeted field investigations the occurrence of at least 90 percent of the species of vertebrates and vascular plants currently estimated to occur in the park.

2. To describe the distribution and relative abundance of species of special concern, such as Threatened and Endangered species, exotics and other species of special management interest occurring within park boundaries.

3. To provide the baseline information needed to develop a general monitoring strategy and design that can be implemented by parks once inventories have been completed, tailored to specific park threats and resource issues.

4. To develop a coordinated network data management effort which results in biological resource information being easily accessible to park managers, resource managers, scientists and the public.

II. BIOPHYSICAL OVERVIEW OF NORTHERN COLORADO PLATEAU NETWORK

The network lies predominately within the Colorado Plateau physiographic province (13 of 16 parks), but also includes two parks (FOBU, TICA) within the central Rocky Mountain Province and and one park (GOSP) within the Great Basin Province. Following is a general description of the physical setting and vegetation for the Colorado Plateau portion of the network. Descriptions of the biophysical setting for the other parks are located in Appendix A.

Physical Setting. The distinctive Colorado Plateau physiographic province covers approximately 335,000 km^2 between the Rocky Mountains and the Great Basin in western North America (Hunt 1974). This unique region is characterized by a suite of outstanding physiographic features that strongly influence ecological patterns and processes found in Plateau parks and monuments managed by the National Park Service and the Bureau of Land Management. These features include:

- *Striking structural geology*, with extensive areas of nearly horizontal sedimentary formations consisting of shales, sandstones, and limestones possessing diverse physiochemical characteristics; great upwarps that form dramatic topographic and geomorphic features; and numerous igneous structures, including volcanoes and cinder cones, basalt-capped mesas and plateaus, as well as laccolithic mountains caused by igneous intrusions (Hunt 1974);

- *Great altitude and topographic relief*, with elevations ranging from less than 1100 m to over 3850 m, and the majority of the Plateau over 1500 m;

- *Deeply incised drainage systems*, responsible for steep-walled canyons and abrupt topographic variations in environmental conditions;

- *Aridity*, with riparian corridors and moist, montane islands distributed sparsely within an otherwise dry environment; and

- *Extensive areas of raw, exposed geologic substrates*.

The Plateau is divided roughly into two climatic regions by a broad, northeastward-trending boundary which extends diagonally from northwestern Arizona to north-central Colorado (Mitchell 1976, Peterson 1994). This broad boundary coincides with the mean northwestern extent of summer precipitation associated with monsoonal circulation patterns carrying moisture from the Gulf of Mexico and the Gulf of California. Approximately two-thirds of the Plateau lies southeast of this climatic boundary and is characterized by a bimodal precipitation regime with both winter and summer maxima. The magnitude of the summer precipitation maximum generally weakens from southeast to northwest, and the northwestern one-third of the Plateau is dominated by winter precipitation. Interannual shifts in the monsoon boundary produce considerable variations in levels of summer precipitation across much of the Plateau. Due to aridity and the vast extent of relatively unweathered geologic substrates, dominant soil orders on the Plateau are Entisols and Aridisols (Birkeland 1999).

Climatic and Edaphic Controls. The composition, structure, and distribution of vegetation on the Colorado Plateau are strongly influenced by factors arising from the particular climatic and geologic characteristics of the region (Comstock and Ehleringer 1992). Foremost among these are variables affecting the spatial and temporal availability of water to plants. The amount and seasonality of effective precipitation (as modified by elevation and topographic exposure), in combination with edaphic characteristics including salinity, texture, and soil depth, structure communities through effects on the hydrologic regime (Caldwell 1985, Comstock and Ehleringer 1992). Though less studied, climatic and edaphic constraints on nutrient relations may be as important for plants in these arid and semiarid environments as the corresponding constraints on water relations (Chapin 1991, Miller 2000).

Although ultimate mechanisms underlying observed plant-soil relationships often are unclear, edaphic control of vegetation remains an important ecological principle on the Colorado Plateau (Welsh 1978, Betancourt 1990). Species distributions tend to be correlated with geology, particularly where relatively unweathered strata remain exposed at the surface (Welsh 1993). Species occurring on raw lithic or unweathered colluvial surfaces tend to be substrate specialists, whereas generalist species tend to occupy alluvial surfaces that have undergone a greater degree of chemical weathering and soil development (Welsh 1993). Consistent with this principle, plant endemism on the Colorado Plateau is highly correlated with the exposure of unweathered colluvium or raw geologic substrates (Welsh 1978, 1993).

The Colorado Plateau is a center of plant speciation and endemism. Although no attempt has been made to determine the size of the flora, there are an estimated 2500-3000 species. About 10% of this flora is endemic (Schultz 1993), consisting mostly of herbaceous dicots in the genera *Astragalus*, *Cryptantha*, *Erigeron*, *Eriogonum*, *Gilia*, *Phacelia*, and *Penstemon*. Many of these species occur in or are adjacent to parks on the Plateau.

Major Vegetation Types. Most contemporary ecologists agree that vegetation composition varies continuously along environmental gradients in space and time (Whittaker 1975, Crawley 1997). Distinct vegetation types are abstractions recognized where environmental gradients are particularly steep or abruptly discontinuous, and where categories are required for convenience of description. This description of major vegetation types found on the Colorado Plateau generally follows treatments of Barbour and Billings (2000); species nomenclature follows Welsh et al. (1993).

<u>Saltbush-Greasewood Shrublands</u>: dominated by perennial shrubs and dwarf-shrubs of the Chenopodiaceae, these communities typically (but not universally) are associated with saline soils of basin bottoms, riparian terraces, and badland substrates on marine shales (West and Young 2000). Common shrub or dwarf-shrub species include *Atriplex canescens*, *A. confertifolia*, *A. corrugata*, *Ceratoides lanata*, *Grayia spinosa*, *Sarcobatus vermiculatus*, and *Suaeda* spp. Typical herbaceous components include grasses *Distichlis* spp., *Sporobolus airoides*, *Elymus cinereus*, and forbs (both exotic) *Halogeton glomeratus* and *Salsola* spp. This type also is referred to as "salt-desert scrub" (West and Young 2000).

<u>Blackbrush Shrublands</u>: dominated by the shrub *Coleogyne ramosissima*, this type usually is associated with residuum derived from calcareous geologic substrates, soils characterized by a shallow petrocalcic ("caliche") horizon, or with carbonate-stabilized sand dunes. With the exception of occasional *Ephedra* spp., *Gutierrezia* spp., and *Opuntia* spp., other woody plants are uncommon in blackbrush shrublands. Common herbaceous species include the grasses *Hilaria jamesii*, *Stipa hymenoides*, and *Sporobolus* spp. In this community type, relative dominance generally shifts from blackbrush to perennial grasses along a gradient of increasing depth to the petrocalcic horizon or the underlying geologic substrate.

<u>Galleta—Three-awn Shrubsteppes</u>: this type occurs on relatively deep and undeveloped sandy soils, most commonly in the Canyonlands section of the Colorado Plateau province (West and Young 2000). Dominant species include the grasses *Hilaria jamesii* (galleta), *Stipa hymenoides* (Indian ricegrass), and *Aristida* (three-awn) spp. The dwarf-shrub *Gutierrezia* and the chenopod shrubs *Atriplex canescens* and *Ceratoides lanata* also are common.

Great Basin Sagebrush: dominated by *Artemisia tridentata* (sagebrush), this is the major sagebrush community found throughout all but the northern-most portions of the Colorado Plateau (West and Young 2000). Sagebrush typically accounts for greater than 70 percent of the live vascular plant cover in this vegetation type, with *Chrysothamnus* spp. and *Elymus elymoides* as the most common co-occurring shrubs and grasses, respectively. The type typically is found on relatively deep alluvial soils.

Sagebrush Steppe: this sagebrush type also is dominated by *Artemisia tridentata*, but is found at higher latitudes and elevations than Great Basin sagebrush (West and Young 2000). It is the major sagebrush type found at Dinosaur National Monument, at the northern margin of the Colorado Plateau. As suggested by the name, the comparatively mesic sagebrush steppe usually is codominated by perennial grasses such as *Elymus smithii*, *E. spicatus*, *E. lanceolatus*, *Festuca idahoensis*, and *Stipa thurberiana*.

Pinyon-Juniper Woodlands: coniferous woodlands dominated by various species of pinyon and juniper are widespread across the Colorado Plateau (West and Young 2000, McPherson 1997). *Juniperus osteosperma* is the dominant juniper on the Plateau, although it tends to be replaced by *J. monosperma* at the eastern and southern margins. *Pinus edulis* is the dominant pinyon throughout the region. Both juniper and pinyon are substrate generalists capable of establishing in rocky soils derived from a wide range of geologic parent materials (Harper and Davis 1999, West and Young 2000). However, understory components of this community type are strongly affected by substrate characteristics, resulting in considerable compositional variation among assemblages broadly grouped together as pinyon-juniper woodlands (West and Young 2000).

Mountain Mahogany-Oak Shrublands: transitional between pinyon-juniper woodlands and lower montane coniferous forests, these mostly deciduous, montane shrublands typically are dominated by *Cercocarpus ledifolius*, *C. montanus*, and *Quercus gambelii*. Evergreen oaks (e.g., *Q. turbinella*) enter this association at the southern margin of the Plateau. Other shrubs common to this vegetation type include *Amelanchier* spp., *Symphoricarpos* spp., and *Purshia* spp. This type also is referred to as "mountain brush."

Ponderosa Pine Woodlands and Forests: dominated by *Pinus ponderosa*, this is the major vegetation type of the Mogollon Rim region of the southern Colorado Plateau as well as the lower montane zones on mountains elsewhere on the Plateau (Peet 2000). Tree density and understory composition in this type are strongly dependent on disturbance history.

Douglas Fir Forests: dominated by *Pseudotsuga menziesii*, this forest type often replaces *Pinus ponderosa* forests successionally in the absence of fire, and spatially along a gradient of increasing soil moisture (Peet 2000).

Aspen Forests: dominated by *Populus tremuloides*, these forests often replace those dominated by *Pinus ponderosa* and/or *Pseudotsuga menziesii* following fire and are subsequently replaced again by the conifers following long fire-free periods (Peet 2000). On the Colorado Plateau, clonal aspen populations appear to have dominated some high-elevation shale-derived soils for thousands of years due to edaphic constraints on conifer establishment (Betancourt 1990).

Spruce-Fir Forests: characteristic of the subalpine zones of Colorado Plateau mountains and the Rocky Mountain region generally, these forests typically are dominated by *Picea engelmannii* and *Abies lasiocarpa* (Peet 2000).

Alpine Tundra: this herbaceous vegetation type on the Plateau is restricted to the highest peaks of the San Francisco, La Sal, and La Plata mountains (Barbour and Billings 2000).

Wetlands: herbaceous plant communities dominated by sedges (*Carex* spp.), rushes (*Juncus* spp.), spikerushes (*Eleocharis* spp.), and cattails (*Typha* spp.) are present but uncommon on the Colorado Plateau (West and Young 2000). Because of their comparative rarity and diversity, as well as their association with surface water, these important communities and habitats possess particularly high conservation value.

Riparian and Canyon Woodlands: woody riparian communities dominated by *Populus fremontii* and *Salix exigua* are important at low and intermediate elevations across the Colorado Plateau (MacMahon 1988). In many drainages, these native cottonwoods and willows face considerable competition from exotic *Tamarix* spp. and *Eleagnus angustifolia*. At higher elevations, comparable communities are dominated by *Populus angustifolia*, *Alnus* spp., *Acer negundo*, *Betula occidentalis*, *Shepherdia argentea*, and several *Salix* spp. (Peet 2000).

Hanging Gardens: these unique, insular riparian communities located in rock alcoves and beneath canyon pour-offs are lush and biotically diverse (Welsh and Toft 1981, Fowler 1995). Common species include *Adiantum capillus-veneris*, *Petrophytum caespitosum*, *Epipactis gigantea*, *Carex aurea*, and *Mimulus* spp. Several Colorado Plateau endemics are found almost exclusively in hanging gardens, including *Primulus specuicola* and *Cirsium rydbergii*.

Biological Soil Crusts. In addition to vascular plants, biological soil crusts composed of cyanobacteria, mosses, lichens, liverworts, microfungi, and green algae are ecologically significant components of many ecosystem types on the Colorado Plateau (Harper and Marble 1988, Johansen 1993, Belnap and Gillette 1998, Evans and Johansen 1999, Evans and Belnap 1999). In the absence of soil disturbance, these microphytic soil-surface communities are found in saltbush-greasewood shrublands, blackbrush shrublands, galleta—three-awn shrubsteppes, sagebrush steppes, Great Basin sagebrush shrublands, and pinyon-juniper woodlands. Total cover of biological soil crusts often approaches and even exceeds that of vascular plants in many communities (Kleiner and Harper 1977, Harper and Marble 1988).

III. DESCRIPTION OF PARK BIOLOGICAL RESOURCES AND MANAGEMENT

A detailed overview of park history, biological resources, and management concerns is provided for each of the 16 parks in Appendix A. These park summaries contain the following sections: size, park history and purpose, location, elevation, general description, flora, fauna, unique features and species of special concern, resource management concerns, and references cited. Maps of each park showing topography, hydrography and locators are found in Appendix B.

Several management issues emerge as being of concern to multiple parks in the network including: invasive plants and animals, recreation use impacts, fire, livestock grazing, and management of threatened, endangered, and sensitive plants and animals. At some level *all* parks are concerned the rapid spread of invasive plant species. Several parks list similar habitats of special concern, especially an array of aquatic and riparian habitats including: riverine habitats, seeps, springs, hanging gardens, and wetlands. A few parks identified the lack of basic biological information as a major obstacle to sound resource management.

IV. EXISTING INFORMATION ON VASCULAR PLANTS AND VERTEBRATES

Existing information on vertebrates and vascular plants in network parks is generally not well organized nor easily accessible. This information is scattered throughout a variety of NPS offices, files and databases, as well as located at external institutions. As part of the inventory project we have begun the task of assembling relevant data on vascular plant and vertebrate species occurrences. We reviewed project reports and published papers to determine the approximate completeness of inventories of all major taxonomic groups. A summary of the status of existing inventories by taxonomic group for all 16 parks in the network is located in Appendix C. As the reader will note, many of the existing inventories are several decades old and of questionable quality and in some cases inventories are lacking all together. Due to turnover of park personnel and the resulting lack of specific knowledge of past biological work in the parks, it has been a challenge to assemble a complete picture of past inventory work. It is likely that additional information exists, however, it is not known at this time. We will continue to compile and catalog additional species information throughout the course of this project.

We are using several NPS national databases to organize this information including: NPSpecies, Natural Resource Bibliography (NRBib), and Dataset Catalog. In addition, the ANCS+ and Investigators Annual Report Databases are serving as information sources for species information.

NPSpecies Database. So far most of our data management efforts have centered on assembling species list and occurrence data for NPSpecies. During the months of May and June we compiled existing species list and voucher information for all 16 parks in the network. Much of this data was only available in paper form, which required manually entering species lists into electronic Excel spreadsheet format. These electronic species list files, as well as ANCS+ voucher data for all parks were sent to Mark Wotawa with the I&M office in Ft. Collins for processing. Mark and his crew expedited the data assistance request and processed NPSpecies files were returned to the network during the month of July. Network biotechs worked with park personnel in cleaning up the species lists and adding reference and voucher information. The process of adding voucher information to the NPSpecies database will be ongoing in the early years of the inventory project. We also have obtained voucher information from the Automated National Catalog System (ANCS+) park databases and it has been converted to the NPSpecies format. Several problems exist with the ANCS+ data including the inability to sort on location (eg. Park vs. outside of park), outdated nomenclature and misidentified specimens. An initial draft of the NPSpecies database for NCPN parks is being provided to the National Inventory and Monitoring Program in October 2000.

NRBib Database. We have just started working with the NRBib database in Procite. An extensive NRBib database population effort was completed on the Colorado Plateau in the mid 1990s. Over 4392 records are contained in the database for the network. Data entries include more typical bibliographic references such as reports and publications. In addition, the NRBib database includes reference to manual and electronic datafiles, photos and raw data sheets. The quality of the NRBib data for most network parks is poor. Citations are typically incomplete and often lack key fields including author, date, place of publication, and number of pages. The task of cleaning up the NRBib data for our network is a big one. We anticipate that this will be an ongoing effort throughout the project.

Dataset Catalog. We have recently obtained a beta version of the new Dataset Catalog and we are in the process of familiarizing ourselves with it. This database stores metadata on a variety of datasets. We intend to use this database to compile metadata on inventory and monitoring datasets for the network. There presently appears to be some overlap between the Dataset

Catalog and NRBib – it would be helpful if the national office could clarify the relationship of these two databases.

Maps and GIS Themes. Spatial Data is an extremely important component of the network's inventory and monitoring program. This data will be useful in selecting inventory and monitoring random sampling locations (e.g., stratification). In addition, GIS will be used to organize data on species occurrences, sampling points, survey routes and much more. We have completed an initial assessment of GIS layers currently available to the network parks (Appendix D). Most parks have basic topographic coverages available, where geological and vegetation information is more limited.

Voucher Specimens & Photographs. So far the network's emphasis on assembling voucher information to document species occurrences in parks has centered on obtaining data from the Automated National Catalog System (ANCS+) for 15 of the 16 parks. In addition, we have obtained mammal, reptile and amphibian voucher data from the Museum of Southwestern Biology in Albuquerque. To date we have not had time to examine what voucher photograph resources may be available for individual parks. We will continue work on assembling voucher specimen and photograph documentation as part of the overall inventory project.

Observation Records. Most parks have utilized Wildlife Observation Cards to document observations of species by park personnel and visitors. In some cases this information has been converted to electronic formats. Observation card data is often of questionable quality and we have generally not included this data in our initial NPSpecies database work. We will assess the potential use of observation data further as the inventory project proceeds.

Inventory Completeness. The first objective of the inventory program is to complete general inventories to document the presence of 90% of all vertebrates and vascular plants within each park. Within the timeframe for completing this study plan we have not had an opportunity to complete a definitive assessment of inventory completeness. As a first step, park resource managers have made a preliminary estimate of inventory completeness (Table 2). These estimates are being utilized to guide allocation of inventory effort at this time. However, as more data becomes available, we will adjust inventory needs accordingly. Assessing inventory completeness will be ongoing throughout the project period.

Several methods are available for determining whether the inventories have reached the 90% completeness level. The NCPN will use a variety of approaches depending on the type of data available. For most parks and taxonomic groups we anticipate using the 'master species list' approach where range maps and expert opinion are used to generate a list of species which are expected to occur within the park. The total number of species documented as present in a given park are then compared with the total number of species on the 'master list' to determine how complete the inventory is. The NCPN has solicited assistance from subject matter experts in development of the master species lists for birds, mammals, herps, fish and vascular plants.

Where we have suitable data we will use other techniques of estimating species richness including species accumulation curves over time or area. These techniques are preferred to the 'master species list' approach and will be utilized wherever possible.

Table 2. Estimated completeness of biological inventory by taxonomic group for network parks (based on best initial estimates from parks).

PARK CODE	BIRDS	MAMMALS	HERPS	FISH	PLANTS
ARCH	90%	85%	85%	90%	90%
BLCA	80%	65%	70%	80- 90%	60%
BRCA	90%	90%	80%	~~	90%
CANY	90%	85%	80%	90%	90%
CARE	94%	65-70%	50%	90%	90% +
CEBR	80%	50%	66%	~~	90%
COLM	90%	80%	80%	~~	90%
CURE	80%	75%	0%	90%	60%
DINO	70%	90%	80-90%	90%	75%
FOBU	80%	80%	85-90%	~~	90%
GOSP	50%	50%	50%	~~	90% +
HOVE	90%	75%	70%	~~	75%
NABR	90%	85%	85%	~~	90%
PISP	98%	20%	40%	~~	90%
TICA	50-60%	50-60%	50%	90%	50-60%
ZION	98%	75%	70%	90% +	90%

V. PRIORITIES FOR ADDITIONAL WORK

Biological inventory priorities for parks within the network were determined though a series of meetings and an evaluation of existing inventory information (discussed in previous section; Appendix C). The Network I&M Steering Committee held a scoping meeting on February 23rd. At this meeting the committee developed a matrix of estimated completeness of presence-absence inventories for each taxonomic group within a park, as well as a list of habitats of special concern and associated stressors. Following this meeting a general evaluation of the status of existing inventories was made and used to refine the estimated inventory completeness matrix (Table 2) and to develop a detailed list of inventory needs for each of the 16 parks within the network.

An experts workshop was held in Moab May 23-25 and brought together 60 subject matter experts and National Park staff to determine inventory priority projects to include in the NCPN study plan. The needs list referenced above was used as a basis for individual taxonomic group discussions and priority setting. The experts workshop was held jointly with the Southern Colorado Plateau Network. Between the two networks 35 individual parks were represented at the workshop. Among the reasons for holding the workshop jointly were to access the same subject matter experts and to select comparable inventory and monitoring protocols across the two networks comprising the Colorado Plateau. Additionally we wanted to explore possibilities for project collaboration across the two networks. Immediately following the workshop the NCPN Steering Committee met to finalize inventory funding priorities for the network.

Three categories of inventory needs have been identified and evaluated: 1) general presence-absence inventories, 2) species of special management concern, and 3) special habitats and communities of concern. Identified inventory needs for NCPN parks far exceeds the amount of funding currently available. Since many parks in the network are lacking basic information on which species are present, the NCPN Steering Committee decided that completing general vascular plant and vertebrate inventories is the highest priority for funding. Inventory of specialized habitats (e.g., riparian areas) will be emphasized in the general inventories since these areas often support high species diversity and species of special concern. We present a listing and description (Appendices E and F) of all identified inventory projects, even though these needs exceed current funding levels.

GENERAL PRESENCE-ABSENCE INVENTORIES

The overall goal of the general taxonomic group inventories is to document the presence of 90% of all vascular plants and vertebrate taxa in a park using scientifically valid techniques. Specific methods for these inventories are presented in Section VI. The estimated priority status of general inventories by taxonomic group are summarized for the NCPN parks in Table 3. These estimates of need and priority are based on currently available information. We view the inventory process as iterative, and we anticipate that as new data becomes available there will be a need to make adjustments to the overall inventory plan. We will place a high priority on maintaining a flexible approach throughout the course of this project.

Table 3. Estimated Status of General Inventory and Priority for Parks within the Northern Colorado Plateau Network.

	BIRDS	MAMMALS	HERPS	FISH	PLANTS
ARCH	X	Medium	Medium	X	X
BLCA	Medium	High	High	X	High
BRCA	X	X	Medium	~~	X
CANY	X	Medium	Medium	X	X
CARE	X	High	High	X	X
CEBR	Medium	High	High	~~	X
COLM	X	Medium	Medium	~~	X
CURE	Medium	Medium	High	X	High
DINO	High	X	Medium	X	High/Medium
FOBU	Medium	Medium	Medium	~~	X
GOSP	High	High	High	~~	X
HOVE	X	Medium	High	~~	Medium
NABR	X	Medium	Medium	~~	X
PISP	X	High	High	~~	X
TICA	High	High	High	X	High
ZION	X	Medium	High	X	X

Note: An 'X' indicates that the inventory is complete. 'High' priority indicates that inventory completeness for a given park is below 75%. 'Medium' priority indicates that inventory is between 75 and 85% complete. A shaded cell indicates that general taxonomic group inventories will be completed as part of this project.

The Northern Colorado Plateau Network has identified specific general inventory projects in order to meet the goal of 90% complete vascular plant and vertebrate inventories in all parks. Following is a listing of planned projects by taxonomic group. These general surveys are being designed to also obtain distribution and abundance information of species of special concern where applicable. Detailed project statements documenting objectives, methods, implementation schedule and budgets for these biological inventories are located in Appendices E and F. Projects proposed for Inventory funding under this study plan are found in Appendix E. Additional unfunded inventory projects are described in Appendix F. Funding status for the projects listed below is coded as follows: IM= projects covered by inventory and monitoring funding, U = unfunded at this time, and O= funded from other sources.

All Taxonomic Groups. The NCPN intends to fund a combination of permanent and term positions to oversee project coordination, development and data management. Inventory funding will cover a portion of the costs associated with these positions. The remaining funding will come from the monitoring phase of the program which will be initiated in Fiscal Year (FY) 2001.

ALLTAX – 01	All Parks	Inventory Project Coordination and Data Management	IM

Birds. General bird inventory work is estimated to be complete in nine of the NCPN parks. Field inventory work is needed in 7 of the 16 parks. Also planned are additional searches of museum collections for voucher information.

BIRDS – 01	GOSP, TICA, DINO, FOBU, CEBR	General Bird Inventory	IM
BIRDS – 02	BLCA, CURE	General Bird Inventory	IM

Mammals. Basic mammal field inventory work is needed in all or portions of 14 parks in the NCPN. Searches of museum collections for mammal vouchers will be conducted as part of these inventories.

MAMMALS – 01	BLCA, CURE, CEBR, FOBU, HOVE, GOSP, PISP, TICA	Mammal Baseline Inventories	IM
MAMMALS – 02	ARCH, CANY, CARE, COLO, NABR, ZION	Focused inventories for Mammals	IM

Reptiles and Amphibians (Herps). Amphibian and reptile inventory work is needed in all 16 network parks, many of these being a high priority. Searches of museum collections for voucher information will be completed as part of these inventories.

HERPS – 01	High Priority: BLCA, CARE, CEBR, CURE, GOSP, HOVE, PISP, TICA, ZION Medium Priority: ARCH, BRCA, CANY, COLM, DINO, FOBU, NABR	General Amphibian and Reptile Inventories	IM

Fish. Fish are known to be present in only eight of the 16 park units in the network and inventories are generally considered complete. No general inventories are planned at this time. There is, however, unverified information on the presence/absence of certain fish at Arches National Park and Hovenweep National Monument. We will investigate this situation further, and if necessary identify inventory needs in outyears.

Vascular Plants. General inventories are thought to be complete for 11 of the 16 parks. Five of the 16 parks are in need of vascular plant field inventory work in all or portions of each park. Existing information on vascular plant distribution will also be compiled as part of the general inventories.

PLANTS – 01	All Parks	National Park and Regional Herbaria Search	IM *
PLANTS – 02	HOVE	Floristic Inventory	IM
PLANTS – 03	TICA	General Floristic Inventory	IM
PLANTS – 04	BLCA/CURE	General Floristic Inventory	IM
PLANTS – 05	DINO	Floristic Inventory of the Green River District	IM

* indicates partial funding from inventory program

Other. Due to special circumstances at Timpanogos Cave NM (TICA) we are planning one inventory that extends beyond the vascular plant and vertebrate species aspect of the project. The primary resource feature at TICA is the cave ecosystem, yet baseline information on cave biota is lacking. Planned is a basic inventory of cave biota.

CAVE – 01	TICA	Cave Biota Study	IM

SPECIES OF SPECIAL MANAGEMENT CONCERN

Parks within the NCPN are responsible for managing a variety of species of special management concern. These include threatened, endangered and sensitive plant and animal species, invasive exotic plants and animals, and other special situation species (e.g., safety concerns).

***Threatened, Endangered and Sensitive Species**.* A list of threatened, endangered and sensitive plants and animals for each park are found in Appendix G. This list was obtained from a new draft national NPS database of TES species and is in need of review. Inventory work has been completed for most listed threatened and endangered species within the network and parks are well into monitoring many of these species (Appendix C). In limited situations inventory for listed species is still needed.

Information on distribution and abundance of many sensitive plants and animals is limited for many parks. General inventories will include a focus on obtaining this information for species and habitats of special concern. In some cases inventory needs for special status species will not be met through the planned general inventory work, and we have therefore identified the following projects. As in the previous section, funding status for the project lists below is coded as follows: IM= projects proposed for inventory and monitoring funding, UN= unfunded at this time, and O= funded from other sources.

All Taxonomic Groups. Knowledge of the occurrence and distribution of sensitive species within parks is extremely variable across the network. Standardized lists of sensitive species are lacking for parks within the network. Specific inventory needs and priorities for these taxa will be clarified through this project.

ALLTAX – 02	All Parks	Develop standardized ‘sensitive’ plant and animal species lists for network parks, and assemble occurrence information.	IM

Birds. Several species specific inventory projects are proposed for special status birds.

BIRDS – 03	BLCA, CURE, CARE, HOVE, ZION, (MEVE)	Southwestern Willow Flycatcher and Yellow-billed Cuckoo Inventory	IM
BIRDS – 04	ARCH, CURE, CANY	Western Burrowing Owl	U
BIRDS – 05	All Parks	Golden Eagle Inventory	U
BIRDS – 06	CEBR, COLM, DINO	Northern Goshawk Surveys	U
BIRDS - 07	FOBU, GOSP	Sage Grouse Inventory	U

Mammals. Two projects are proposed for special status mammals within the NCPN. These inventory needs will not be met by the planned general inventories.

MAMMALS - 04	ARCH, CANY, DINO	Northern River Otter	U
MAMMALS – 05	DINO, FOBU	Selected Mammal Species of Special Concern Inventory	U

Reptiles and Amphibians (Herps). At this time the network does not have enough information on special status amphibians and reptiles to fully evaluate inventory needs and only one project is proposed at this time. General inventories for reptiles and amphibians will result in additional distribution and abundance information on special status species.

HERPS – 02	CARE	Chuckwalla	U

Fish. Three fish inventories for special status fish species have been identified.

FISH - 01	CARE	Field survey for roundtail chub (*Gila robusta*) along Halls Creek	U
FISH - 02	CURE	Colorado Cutthroat Trout Survey	U
FISH - 03	BLCA	Black Canyon Fish Survey	U

Vascular Plants. For many parks in the network knowledge of plant species of special concern is limited. At this time we do not have enough information to fully assess what inventories are needed for these species. Two parks within the network, Dinosaur NM and Capitol Reef NP are well-known centers of plant endemism. Detailed studies of endemic plant taxa have been completed or are on-going within Dinosaur NM. During the past few years Capitol Reef NP has been actively conducting inventories for numerous endemic plant taxa, including several listed species. So far inventories have been completed for six high priority taxa within high use visitor areas. A three-year parkwide inventory of plant endemics was launched this year (FY2000) using Natural Resources Preservation Program (NRPP) funding. This inventory will contribute significantly to the knowledge of the abundance and distribution of these species. The sensitive plant inventory projects below have been proposed for parks where general plant inventory work is already complete.

PLANTS – 06	ARCH, NABR	Sensitive Plant Inventory for Southeast Utah Group Parks	U
PLANTS – 07	BRCA, CEBR, ZION	Sensitive Plant Inventory for Three Parks	U
PLANTS – 08	FOBU	Sensitive Plant Inventory for Fossil Butte NM	IM
PLANTS - 09	CARE	Parkwide TES Plant Surveys	O

Invasive Exotic Plants and Animals. Most parks in the network identified invasive non-native plants as a significant management concern. Some parks such as DINO and SEUG (ARCH, CANY, NABR and HOVE) have active programs aimed at controlling high priority invasive plants. The Intermountain Region of NPS is about to initiate development of a region-wide strategy for invasive species. A goal of this strategy will be to identify and map all alien species in each park. It will be important to make a connection between the invasive species strategy and network level inventory and monitoring programs. Although we know that there are extensive needs for inventory of invasive exotic species we were not able to conduct a full analysis of this need as part of the current study plan. Distribution and abundance data on invasive plants will be collected as part of the general plant inventory work in the few (5) parks scheduled for this work. Below we have identified a team approach to obtaining distribution and abundance information on important exotics in multiple network parks. This project is currently unfunded, however, the network will agressively seek funding for this project from other sources.

EXOTIC – 01	All Parks	Multi-park Invasive Plant Inventory Project	U

Other Species of Management Concern. Park managers may also be concerned with other types of species, for a variety of management reasons. For example, several Colorado Plateau (northern and southern) parks identified mountain lions as being of concern from a human safety perspective. At the experts workshop it was suggested that a Colorado Plateau wide workshop would be an appropriate starting point for dealing with this issue. This project has been identified as a jointly funded and sponsored effort with the Southern Colorado Plateau Network. At this time the NCPN has not selected this project for immediate funding. We would like to work closely with the Southern Colorado Plateau Network in further developing the concept of this workshop to ensure useful products will follow. We will reconsider funding for this project at that time.

MAMMALS - 06	All Parks	Large Carnivore Workshop	U

HABITATS AND COMMUNITIES OF SPECIAL CONCERN

Inventory of special habitats of concern is a critical component of the overall inventory effort. Network parks have identified high priority habitats in Table 4 that will be addressed in the general inventory efforts (see Section VI). Most of these habitats are associated with water and include rivers, seeps, springs, hanging gardens, and wet meadows. These specialized habitats often hot spots for biological diversity and support numerous species of special concern. Habitats associated with water may often be threatened by impacts from focused visitor and livestock use (when present).

Table 4. Habitats of special concern with associated stressors for parks in the Northern Colorado Plateau Network.

Park	**Habitat Concerns**	**Stressors**
ARCH	Seeps & springs, fir habitat	Exotics, developments
BLCA	Seeps & springs, riparian, hanging gardens	Grazing-cattle, exotics, land use conversion
BRCA	Springs, breaks, & aspen	Exotics, grazing, visitor use, forest succession
CANY	Seeps & springs	Exotics, development
CARE	All wetland areas	Exotics, road maintenance, visitor use, grazing
CEBR	Disappearing spruce, bristlecone pine, wet meadows, springs	Spruce bark beetle, exotics, impending fire
COLM	Riparian, seeps & springs, hanging gardens, relic areas	Visitor use, exotics, external development
CURE	Seeps & springs, riparian, hanging gardens	Grazing-cattle
DINO	Riparian, river, seeps & springs, mountain shrub lands, hanging gardens, crust communities, montane	Grazing, water quality and flow, exotics, past fire, exclusion, toxic spills, habitat fragment, back country, air quality, maintenance
FOBU	Riparian, seeps & springs, mountain shrub, aspen	Exotic plants, over-browsing, fence maintenance
GOSP	Sagebrush, grass distribution	Exotics, adjacent land uses
HOVE	Seeps & springs	Exotics, development
NABR	Seeps & springs	Exotics, development, visitor use
PISP	Springs	Loss of water, exotics
TICA	Cave	Human impacts
ZION	Riparian, springs, aspen, white fir, slot canyons, hanging gardens	Visitation, change in use patterns, adjacent development, exotics, threat of catastrophic fire, water Q&Q, too many mule deer

VI. SAMPLING DESIGN CONSIDERATIONS AND METHODS

DESIGN CONSIDERATIONS

Northern Colorado Plateau Network parks have given thoughtful consideration to the design of this inventory project. We will use a combination of sampling approaches depending on the status of inventory completeness for a given taxonomic group within a park and the size of the park.

Parks with Mostly Complete Inventories. Due to the advanced stage of inventory completeness (>65%) for most parks in the network (Table 2), we have opted to emphasize targeted inventories to fill gaps, as opposed to designing a comprehensive and integrated network inventory program. We realize that there are trade-offs in this decision, and that a stratified random or systematic random sampling design applied more uniformly across entire parks in the network would yield data from which statistical inferences could be made. However, since most parks are between 65 and 90% complete, a parkwide random sampling design would most likely yield information on common and widespread species which are already documented. In addition, inventory funding is not sufficient to implement parkwide integrated inventory for all taxonomic groups in all parks. Given this situation we plan on conducting inventories targeted at specific habitats or geographic areas within the park that are likely to yield data on undocumented species and species of special concern. It is our feeling that this approach will yield the most useful data for resource management in the parks. Managers are in need of specific distribution and abundance information on species of special concern, such as rare plants and invasive exotic plants, and our approach will maximize acquisition of this data.

Target habitats in individual parks will be stratified based on physical and ecological attributes associated with the species and habitats of interest (Table 4; Appendix G) and mapped prior to selecting random sampling locations. Attributes for delineating strata may vary across taxonomic groups and may also be based on what spatial data is available for a given park (Appendix D). For example, plant inventories may be stratified on geologic substrate and bird inventories may be stratified on habitat (e.g., riparian areas). To the degree possible we will attempt to stratify on fixed landscape attributes (e.g., slope, elevation, aspect), however, in some cases it may be necessary to stratify on vegetation or other ecological attributes.

A grid-cell approach of identifying potential sampling locations (Fancy 2000) will be applied to the entire park. The starting point for this base grid will be randomly selected. Stratum of interest will be delineated over the base sampling framework for the park. Once strata have been delineated and mapped using existing GIS datasets, we will sample for the taxonomic group of interest. Within each target stratum, all areas accessible for sampling will have an equal probability of being chosen. Where certain portions of a stratum are inaccessible to sampling, inferences will not be made to these areas. To the degree dictated by need, taxonomic group sampling points may be integrated. Design of inventories for some species of special concern may require departure from a random sampling approach. In these situations data will not be used in model-based estimates of species richness. An example of where such a departure may be warranted is an inventory for a rare plant that is restricted to highly localized outcrops, which would be missed in a random sampling design.

Parks in need of Basic Parkwide Inventories (<50% complete). Six parks (GOSP, TICA, PISP, CARE, CEBR and CURE) in the network have at least one taxonomic group with estimated inventory completeness at 50% or below (Table 2). In the case of GOSP, TICA and PISP, two to four of the taxonomic groups have incomplete inventories (50% or below).

For taxonomic groups at 50% or less inventory completeness we plan on taking a parkwide approach to design of these inventories. For large parks we will use a stratified random approach and for small parks a systematic random design or complete area surveys. Strata will be delineated based on a combination of physical and ecological attributes, depending on need and available spatial data. A grid-cell approach will be utilized to identify all potential sampling locations in the park or within strata. At GOSP and TICA where multiple parkwide basic inventories are needed a focal point approach may be utilized. In this approach focal points will be randomly selected and secondary sampling units for mammals, birds, and herps will be randomly located with respect to the focal point. This approach will allow for integration of taxonomic group data. For inventories of vascular plants in small parks (<121 hectares/300 acres) we will conduct complete systematic inventories of the entire park.

Habitat Variables Common to All Inventories. Consistent descriptions of vegetation types and physical site features will be used to classify all vertebrate sample points. The Northern Colorado Plateau Network will attempt to standardize these variables with the Southern Colorado Plateau Network for consistency. Vegetation types for each sampling location will be classified based on data collected using the releve method from the Colorado Plateau Vegetation Assessment and Classification Manual (Rowlands 1994). More detail on vegetation classification is found in the vascular plant methods section below.

Temporal Aspects of Sampling. In most cases field work for individual projects will be completed over a two year period (not necessarily in consecutive years). Individual taxonomic group inventories will be staggered to ensure seasonal variation in vertebrate occurrences and distributions and phenological variations in plants is captured. Specific timetables for sampling are located in individual project statements (Appendix E).

Sample Sizes. At this time it is not possible to know how many samples will be needed to achieve our inventory goals. Factors influencing the number of samples needed vary with taxonomic group, season, sampling effort, and variability in species occurrences and year-to-year variations. Assessing inventory completeness will be ongoing throughout the project. We will use these assessments to adjust our sampling intensity accordingly.

Limitations in Selecting Sampling Locations. Significant portions of many parks within the network are inaccessible for sampling. Much of the canyon country is highly dissected and without roads and water. Only areas with reasonable accessibility will be included in the sampling pool. Another challenge in selecting sampling locations will be the high incidence of exposed bedrock in the form of slickrock, and the potential for a high number of random points coinciding with slickrodk. Unfortunately the occurrence of slickrock in a park is not easily determined in terms of stratification. Biological soil crusts occur throughout most parks in the network. These crusts are extremely vulnerable to trampling and it will be important to conduct inventories in such ways to minimize impacts.

Relationship of Inventory to Monitoring. Inventories for the Northern Colorado Plateau Network are primarily designed to complete knowledge gaps in basic inventories. Although specific inventory plot locations will be available to future monitoring efforts, we have not emphasized an inventory design that leads to monitoring.

The Northern Colorado Plateau Network will be initiating the monitoring phase of the I&M project during FY01. During this first year we will concentrate on assembling and evaluating existing monitoring data for the parks. In addition, we will begin the process of determining what resource management questions need to be addressed by monitoring and which ecosystem components will be selected for monitoring system integrity. Once monitoring goals and objectives have been identified for network parks then appropriate indicators and study design can be developed and applied. It is unlikely that we will be able to afford total species monitoring across all habitats in all parks. A more realistic approach is that monitoring will likely focus on portions or components of the ecosystem which are threatened and are of management concern. Data obtained during the inventory phase of this project will be helpful for developing the monitoring phase of the program. For example our emphasis on obtaining better distribution and abundance information on species of special concern will provide a stronger basis for developing monitoring protocols for these species when they are needed.

SURVEY METHODS

Described below are the general methods we will draw from to inventory each major taxonomic group. For each we describe the methods used for general inventories as well as individual species or groups of species which require special approaches. The same methods of field sampling will be used in most inventories and will ensure inter-park comparisons. Please note that not all methods described below will be used in each project. The methods specific to each project are described in individual project statements in Appendix E.

We have attempted to standardize core methods for each taxonomic across the Colorado Plateau. We will continue to work with the Southern Colorado Plateau Network to ensure compatibility of methods and data. Although different investigators may be involved in conducting the inventories, the protocols and type of data collected remain the same. This will provide opportunities to compare and analyze data plateau-wide. In addition, all investigators will be required to complete an Investigators Annual Report (IAR) for each inventory project.

Bird Methods

<u>Estimating Richness, Relative Abundance and Density of Breeding Birds</u>. It is rarely possible to count all of the birds that are actually present in an area, and therefore to estimate abundance or density, sampling methods must be used. *Distance sampling* has been used for more than 30 years to estimate animal abundance and has been found to be a reliable method for estimating relative abundance and population trends for many bird species (Fancy 1997, Nelson and Fancy 1999).

Distance sampling is based on the intuitive knowledge that the distance between an observer and an object will effect the probability of detection; the further away an object, the less likely it is to be detected. Data collected are the horizontal distances from an observer to an object. Using these distance we will calculate a detection function, which is the probability of detecting an object given its distances from the observer. This detection function is used to estimate bird density and allows birds to go undetected during a survey (Buckland et al. 1993).

Distance sampling includes two main approaches; line transects and variable circular plots (VCP).

Line Transect Sampling. An observer walks a transect and measures the perpendicular distance to each bird heard or seen. Another option is to record the sighting angle and sighting distance to each bird and convert these to perpendicular distances. Line transects can be very efficient in open habitat because data are collected continually as an observer walks the transect.

Variable Circular Plot Sampling (VCP). An observer stands at a sampling station and records the radial (horizontal) distance between the observer and the bird. VCP are the preferred approach in patchy or densely vegetated habitats and in rugged or hazardous terrain

The choices between using line transects and VCP, the distances between survey routes, and the placement of routes within strata and habitats will be made after further definition of the sampling frame for each individual park. Each route will be surveyed 3 times from mid-April through July, which will coincide with the greatest number of passerine species exhibiting breeding behaviors. Visits will start at one/half hour after sunrise and be completed by 1000. At each point count station one observer will record all birds seen or heard for 10 minutes. During the last 3 minutes of the count, only new species detected will be recorded. To lessen observer influence on birds, counting will begin 1 minute after arriving at a station. Laser rangefinders will be used to measure distances to birds.

Flyover species will be recorded but with no estimates of distance. Birds flushed while walking between point count stations will be counted and their distance to the nearest point count station will be measured.

Data Analysis. Species richness will be calculated as the number of species detected. Estimates of species richness based on mark-recapture models will provide an estimate of the number of species that are probably present, but have not been detected (Dawson et al. 1995, Boulinier et al. 1998). These species richness estimates will be used to assess the adequacy of sampling technique, by comparing the estimated number of species in an area to the actual number counted during surveys (Swann 1999).

Relative abundance and density of each species with >50 detections will be estimated using program DISTANCE (Thomas et al. 1999). The distance data will be used to model detection functions, from which we can obtain unbiased estimates of abundance for each species (Buckland et al. 1993). The advantages in using Distance Sampling data include 1) multiple surveys can be combined to increase sample sizes. By combining surveys, it is possible to estimate densities of many rare species, even in situations where only 1 or 2 birds are detected while sampling many stations; 2) allows for adjustment of different covariates such as observers, vegetation, and detection distances; and 3) able to use historical count data if the park collected bird data using unadjusted point counts and the park then switches to VCP counts.

Additional Breeding and Non-breeding Surveys. Most bird survey methods provide good information for common species and relatively sparse information for rare or secretive species. This does not mean the survey method is invalid, it is simply a reflection of the difficulty of sampling rare and secretive species using general methods. Therefore, in addition to point-counts using distance sampling, systematic searches of special habitats during breeding and non-breeding periods will be completed to increase the chance of detecting rare and secretive species. These special habitats will be defined on a park by park basis, but might include such areas as cliffs, riparian zones, and historical locations of rare species. Selection of habitats to be searched will be conducted after special habitats have been identified and mapped.

During the non-breeding season (November – February) we will conduct three additional visits. These surveys will be conducted between sunrise and 1000, extra visits will be made in the late afternoon that may reveal presence of vultures, buteos, or any other birds not found in early morning (Robbins 1981). Survey data will include species encountered, habitat, location, dates, and evidence of breeding status (i.e., courtship behavior, nests).

Nocturnal Species. Owls will be surveyed using tape playbacks, in randomly selected habitats that owls may occupy or where historical sightings have been noted (Springer 1978, Forsman 1983). Tape broadcasts will be played for 10 minutes followed by a 5 minute listening period at designated points. Surveys times will occur between 1 hour after sunset and 1 hour before sunrise. We will conduct two surveys during the breeding season and two surveys during the non-breeding season. Survey data will include species encountered, habitat, location, dates, and evidence of breeding status (i.e. courtship behavior, nests). Caprimulgids (i.e., *Goatsuckers*) are vocal enough that playback recordings are rarely needed during surveys and will likely be encountered during owl surveys.

Species of Concern. These species have been identified by each park because they have either been federally listed as endangered or threatened such as the Southwestern Willow Flycatcher and Mexican Spotted Owl or listed by the state where the park is located as a species of concern (i.e., Burrowing Owl). Species of concern have also been identified by the park because they are suspected to occur at the extreme edges of their ranges in certain parks, or are suspected to be declining. The methods used to survey for species of concern will depend on behavioral traits and habitat.

Tape Playbacks. Broadcasting tape playbacks has been effectively used to survey for endangered species (i.e., Southwestern Willow Flycatcher; Sogge et al. 1997) and marsh-breeding species (Marion et al. 1981). We will include the playback procedure in habitats that target these species, increasing our chance of detecting these targeted species (Verner and Milligan 1971). Broadcasting of taped calls will occur in the habitats that the standard count survey is not being conducted or after the standard count period is completed.

Mammal Methods

Sampling strategies and methods for mammals will vary from park to park, depending upon the specific objectives as specified in detailed study plans, and perhaps upon availability of plots developed for other groups that also can be sampled for mammals. A combination of designs and methods will provide the most complete coverage of mammals for each park. For example, pitfalls are most effective at capturing shrews, mist nets and bat detectors for bats, various sorts of traps for small and medium-sized rodents, larger traps or firearms for some medium-sized species (e.g., rabbits), and a variety of observational and tracking methods for carnivores and ungulates. Data on larger species (furbearers and game species) may be available from park records and state wildlife investigations. Although several investigators have used remote automated photographic stations to advantage, these studies are usually species-specific and we know of no case where such stations have been used in large-scale studies of species richness.

Inventory methods for mammals of the plateau will follow guidelines enumerated in Kunz (1988) and Wilson et al. (1996). Kunz' (1988) book provides details on an array of capture and research techniques for bats. Wilson et al. (1996) provide a comprehensive collection of papers on measuring and monitoring mammalian diversity including several on aspects of design and randomization.

For mammals in general, we envision a seasonal two-year effort for those parks needing partial or complete inventories. Most work will be done in the summer season and a schedule will be developed so that each park is visited at a different time during the two years of visits. It will be possible to work at some parks (e.g., Zion and others) in late spring or early fall. Work at other times of the year will depend on specific needs as outlined in the individual statements of work; capture of data from park records and files would be done off-season. In some cases, work may last three years on selected parks, depending on the vagaries of climate as well as success in confirming species occurrence.

Shrews are vastly undersampled on the plateau and where complete inventories are called for, some effort will be dedicated to pitfall trapping. Although sites for pitfalls can be chosen randomly, aspects of shrew biology should be applied, as most species of *Sorex* have a preference for more mesic, litter-rich sites. Small plastic cups or buckets, and even bottles, have proven effective as pitfalls for shrews (Jones et al. 1996). The linearity of suitable shrew habitat will influence whether pitfalls are set in grids or lines. In suitable habitat we will install pitfalls at 5-m intervals. Water shrews are most effectively sampled at the edge of small streams with pitfalls spaced at wider intervals (15-20 m). Where possible, drift fences to help “corral” shrews and direct them to the pitfalls will be used. Pitfalls will be unbaited, kept dry, and checked frequently so animals can be released alive.

Pitfalls are also effective for capturing some small heteromyid rodents, such as pocket mice. In suitable habitat, pitfalls for these species will be used. Effort and catch will be quantified for each area based on numbers of nights that a given number of pitfalls are operational (pitfall-nights). It is possible that reptiles and amphibians may be caught in mammal pitfall traps. In this case, mammal investigators will be asked to record and supply data on these herp species.

Small- and medium-sized rodents (including some ground squirrels) are effectively trapped in livetraps such as those made by Sherman or wire traps such as those made by Tomahawk and others; animals can be released unharmed following identification (Jones et al. 1996). For inventory efforts where densities of small mammals are not required, livetraps can be effectively set in lines 150 m in length in appropriate habitat with starting points determined randomly (Jones et al. 1996). Grid designs of traps are more appropriate where densities are needed, as in long-term monitoring, but may miss some species (certain microtine rodents). Two traps will be set per station, and stations will be spaced at 15-m intervals along the line. Additional lines within the same habitat will be spaced at equal intervals. Habitat complexity may require shorter intervals in some cases. Traps will be set for three nights, baited with rolled oats in most cases, checked at least twice per day, and will be closed during daylight hours except for directed efforts on diurnal species. Livetraps will be checked more frequently, up to once per hour, for diurnal species. Where possible, livetraps will be set at habitat features (e.g., logs, trees, burrows) but within 2 m of the station point. Effort and catch will be quantified based on numbers of nights a given number of traps are set (trap-nights).

In selected areas and for selected species, “snap” traps that kill rodents may be used. To the extent possible, kill traps (e.g., Museum Specials, Victor rat traps) will be set in a fashion consistent with livetraps as described above. Kill traps are effective for species that are reluctant to enter box (Sherman-style) traps and are useful and effective in logistically-difficult areas (e.g., cliffs) where a sufficient number of box traps may be difficult to carry or set. A snap trap costs less than half the recommended Sherman trap (LFADTG; ca. $15.00 each) and life spans under normal usage are equivalent. All rodent sampling will be consistent with published guidelines for reducing exposure of trapping personnel to hantavirus and other infectious diseases.

Bats will be sampled in several ways, depending on park size, availability of known or suspected roosts, and presence of water sources. Where roosting sites are known or suspected the sites will be observed without disturbing the bats as the great likelihood is that such aggregations will be maternity colonies (females with young). Such roosts can be selectively and carefully netted from the outside to determine species identification. Detection of roost sites using radiotransmitters affixed to bats will not be emphasized for inventory since this is more of a research question. Bats roosting in small numbers can be hand-captured, identified, and released but such attempts should be used cautiously in maternity colonies. For parks where bats are not readily captured, walking transects will be used to search for bat presence based on observations of guano and insect remains.

All water sources larger than 1 m^2 (arbitrarily) should identified as a “sampling pool” for bats. Most pools at hanging garden sites are not suitable for drinking by most bats, and are typically difficult to net. In addition, netting may damage fragile plants and substrates in these locations. Suitable sites (streams, creeks, stock ponds, etc.) should be netted two to three times per summer season no more often than every four to five days, depending on past success. Where inclement weather results in low capture success the site will be revisited sooner. Effort with mist nets will be quantified based on size and numbers of nets set each night (net-nights). At most water sources on the plateau, 6- and 10 m nets are sufficient although longer nets (14- and 20 m) may be needed at times. Bats will be carefully removed from nets to determine sex, reproductive status, age, and species recorded, and released unharmed. In some cases it may be useful to take selected measurements (mm) or body masses (g). Where there are no water sources over which mist nets can be deployed it may be possible to net areas that intuitively appear to experienced investigators as flyways through which bats might travel. Personnel handling bats will be vaccinated against rabies using the rabies pre-exposure regimen with subsequent testing of rabies antibody titers.

In selected parks or areas, especially those with limited roosts and water sources, it may be necessary to use a bat detector to determine the presence of bats. Sample points or transects can be randomly selected and both species diversity and relative activity levels can be determined at a pre-determined number of points along the line. Most North American investigators use the Australian bat detector Anabat, made by Titley. Typically, calls are recorded on the hard drives of laptop recorders and saved for subsequent analysis. Calls also can be saved on high-quality tape recorders or compact disk devices for analysis. Although randomly chosen bat detector transects may be very useful in long-term monitoring as well, a variety of caveats have been raised about their use in this fashion (O'Shea and Bogan 1999). It is recommended that for parks on the NCP, efforts with Anabat be restricted to identification and confirmation of bat species occurring within the park. This should provide a more cost-effective effort, in conjunction with roost observations, searches, and netting. Also, some species of bats have audible echolocation cries and experienced personnel can recognize those calls to help document presence of some species.

To confirm the presence of some medium-sized terrestrial mammals and all large mammals, especially carnivores, a combination of methods will be used. These will include: review of historic and recent museum records, park staff and visitor files (with caution), field observations (for tracks, scat, sign) by those conducting mammal surveys, photographs, and relevant information from state fish and game agencies. Most small parks will be too small to have any resident carnivores, rather the carnivore's home range may encompass the park or at least the appropriate habitat components that occur on the park. Likewise, for some larger parks and some wide-ranging species of carnivores much of the range of some species will be off the park. Rather than mount an expensive and time-consuming effort to trap such species we recommend that other information sources be used. We believe that this will provide a landscape-level overview of carnivore presence that should be more useful to parks in helping to understand the importance of the park to medium- and large-sized mammals within a regional context. Larger parks will certainly have resident medium and large mammals but we recommend the same methods be used, except in the case of questions about occurrence of selected species on some parks or where identified needs exist.

Finally, there is a suite of perhaps 20 or so medium-sized mammals, many diurnal, that are scansorial, arborial, fossorial or semi-fossorial, and aquatic. Traps (e.g., for gophers) and trapping methods are available for most of these species but some of these species are difficult to trap and some require sedation for handling. For many of these species the most cost-effective way to document presence for initial inventory is probably by observations documented with photographs by knowledgeable personnel and by specimens taken with a firearm. Park records may help confirm presence of some of these species as well.

Reptile and Amphibian (Herp) Methods

A combination of methods will be used to complete reptile and amphibian inventories, as outlined below.

Gathering of existing information. During the fall and winter of the first year, we will conduct searches of existing databases and museums in parks and other institutions for documentation of occurrences of reptile and amphibian species in each park. We will also interview herpetologists that have worked on the Colorado Plateau to gain their insights into where and how to best survey for particular species, as well as to obtain their records of species' occurrences.

Visual Encounter Surveys. Time/area constrained searches (TACS) will be the primary method used for general reptile and amphibian surveys. This technique requires that an area of known size be searched using a variety of techniques, including scanning with binoculars, using mirrors to shine into cracks in search of hidden reptiles and amphibians, and looking underneath cover (Crump and Scott 1994). It is more difficult to replicate surveys if only time spent searching is constrained, plus there are significant issues concerning whether all appropriate "mesohabitats" within a plot are adequately surveyed. Surveys will cover 1 hectare, and encompass a total of 4 person-hours. Ideally, at least 2 herpetologists will conduct each search. Time spent searching will not be counted during processing of any reptile or amphibian encountered, thus actual time taken to search an area by 2 people may take significantly more than 2 hours. There will likely be a number of different "mesohabitats" within a hectare plot (e.g., boulder piles, open shrub or grassland, exposed bedrock, etc.). It is important that each of these receive search effort commensurate with the proportion of the total plot each represents. In situations where the sampling stratum does not contain at least one hectare, the time spent searching should be reduced proportionally to the reduction in area. Thus, if there is 0.5 ha of habitat, 2 person-hours should be spent searching.

While very difficult to conduct in many habitats, there is value in conducting nocturnal TACSs. There will be little opportunity to detect nocturnal species in other ways for many habitats in parks. Night-driving is effective when paved roads are available, but there are few roads in the parks on the Colorado Plateau, and of those roads that do exist, very few are paved. The dark pavement is what generates a warmer surface than surrounding rock or soil that attracts reptiles. There are also many habitats that are not traversed by roads at all, and thus would not be surveyed by night driving.

Nocturnal TACSs will be conducted in the same plots searched by day, during the evening following the daytime searches. Nocturnal searches will encompass 2 person-hours. At least 2 herpetologists will be used for these searches; however, unlike diurnal TACSs where each person can search independently, for safety reasons, technicians will work in 2-person teams to conduct a nocturnal TACS. Each team will be considered a single person for measuring time spent searching. Thus a single team would work for 2 hours to achieve a 2 person-hour search, 2 teams would each search 1 hour.

Night Road Driving. Driving slowly on roads at night is recognized as an excellent method for surveying some groups of amphibians and reptiles, particularly snakes (e.g., Bernardino and Dalrymple 1992, Dodd et al. 1989, Klauber 1939, Mendelson and Jennings 1992, Rosen and Lowe 1994, Sullivan 1981). This method is also effective for surveying amphibians (Shafer and Juterbock 1994), particularly in the arid southwest where many anuran species are seldom active during daytime, but can often be found crossing roads on warm, rainy nights. Night driving was determined to be the best survey method for amphibians in two arid Colorado Plateau National

Park areas during recent inventories at Petrified Forest National Park (Drost et al. 2000 unpubl.) and at Wupatki National Monument (Persons, in progress).

Time and distance covered during a road-driving session should be standardized by driving at a constant speed for a variable time, depending on availability of road to drive. Road-driving should be done with 2 people, driving at 20 mph; to avoid fatigue, no more than 2 hours of night-driving should be done on a given night, especially if crews have been surveying during the day as well. For most parks, all paved road should be driven, for some, there may be more road than can be covered on a single night in 2 hours of driving. In these parks, night-driving should be done on consecutive nights until all roads have been driven. For all driving surveys, it will be necessary to drive the route during the day, either before (preferred since this allows surveyors to become more familiar with the routes) or after the night survey. The daytime drive will be used to record which habitats are traversed, and length of the transect through each habitat.

Identify all amphibians and reptiles encountered to species, record either alive on the road (AOR) or dead on the road (DOR), sex and age all individuals, as possible. Record locations will to the nearest 0.01 mile using calibrated vehicle odometers, and late convert these positions to GIS point locations. Collect animals found DOR and in good condition and preserve as voucher specimens. Occasionally live animals should be collected for voucher specimens, as needed (see “Voucher Specimen Collection” below for details).

In addition to night driving surveys, reptile and amphibian experts should opportunistically record amphibians and reptiles seen on roads during daytime, during the course of travel within the parks. Although less effective and less quantifiable than night driving, due to faster driving speeds and the presence of other vehicles on the road, this is still an effective method for detecting the presence of some diurnal reptiles, such as whipsnakes (*Masticophis*), patch-nosed snakes (*Salvadora*), and horned lizards (*Phrynosoma*).

Amphibian-Specific Methods. Different habitats may need to be surveyed with different methods. Methods described in the Amphibian Research and Monitoring Initiative (ARMI), which is a national effort funded by Congress starting with the FY2000 Department of the Interior (DOI) Budget will be used where applicable. Many of these techniques have been tested in other parts of western North America, but will need some evaluation for effectiveness on the Colorado Plateau.

Visual Encounter Surveys (VES) or similar systems that have proven reliable to detect pond amphibians (Fellers and Freel 1995, Corn et al. 1997, Bury and Major 1997, Olson et al. 1997, Adams 1999) will be used to survey for amphibians at ponds, tinajas, and other lentic habitats. VES have been used at over 150 ponds and wetlands in Olympic Natl. Park, the Willamette Valley of western Oregon, and elsewhere over the last five years. These studies suggest that two VES per season are needed for detectability of species presence and include a spring search (best for locating egg masses) and one later in the summer (time to locate tadpoles and larvae). VES is comparable to techniques used in adjacent montane regions: Rocky Mountains (Corn et al. 1997) and Sierra Nevada (Fellers and Freel 1995). Standard and field proven data forms are available to record basic habitat variables (e.g., pond size, substrate type, vegetation, etc.), but have not been tested in arid and semi-arid environments. As part of the ARMI effort, VES techniques will be evaluated in ponds and tinajas (e.g., plunge pools in rocky canyons) at Canyonlands National Park and vicinity. These aridland efforts will be directed by Dr. Tim Graham, FRESC Canyonlands Field Station, Moab, UT.

In 1996-98, a walking transect (500-m long mapped at 10 m intervals) was developed by scientists at the USGS Forest and Rangeland Ecosystems Science Center, Corvallis, OR, which was useful to survey visually for adult and larval amphibians along 3rd order and larger streams in western

Oregon (Bury et al., in prep.). These long transects were more effective to observe and record amphibians than time- and area-constrained searches (using amount of time invested in each method). Pilot surveys at three stream/riparian zones in Canyonlands Natl. Park and vicinity will be conducted in conjunction with ARMI to test their utility in different ecosystems. If this method is promising, it will be incorporated into the inventory of NCP parks.

Calling surveys, in the form of audio strip transects (Zimmerman 1994) will be conducted during the spring breeding season, and if males are calling during the monsoon season in July and August, these surveys will be repeated. Audio strip transects will be run along the shores of permanent and intermittent stream channels for up to 500 m, depending on available habitat. Calling surveys will also be conducted at lentic habitats (e.g., ponds, tinajas, potholes, and isolated pools in washes following spring rains and flash floods).

Egg mass and tadpole surveys will also be conducted in the same habitats as the calling surveys. Detection of eggs or tadpoles will be used both to directly identify species' presence where this can be determined from egg mass or tadpole characteristics and to identify locations to be targeted in subsequent surveys when metamorphs are available for identification. Both egg mass and tadpole surveys can provide assessments of reproductive effort, and coupled with later counts of metamorphs can yield estimates of survival rates in selected habitats, which could be incorporated into a monitoring program.

Sound-activated recording devices will be used experimentally in a few areas to determine whether these can be used to detect species presence during breeding calling periods in a number of sites, since it is very difficult to mobilize adequate numbers of personnel to visit large numbers of widespread potential breeding sites within a day of an appropriate precipitation event (e.g., heavy thunderstorms), the areal extent of which is uncertain, thus it may not be clear, even if mobilized successfully, where technicians should be sent.

Timing of surveys. Three to four visits per year per park would be ideal, this would allow surveys that coincide with seasonal shifts in activity patterns (e.g., from diurnal to nocturnal), and to accommodate differences in overall active periods of different species. Spring and fall surveys may be expected to have greater success rates for night road-driving, since the contrast between road and surrounding substrate temperatures will be greatest during these seasons; likewise nocturnal TACS on bedrock, especially if dark, may be more profitable in these seasons. Spring and dry summer are the best times to document amphibians that breed in spring--metamorphs are abundant and identifiable, and have not yet dispersed very far from breeding pools for up to 12 weeks after egg-laying. Summer is the period of greatest activity for many reptiles, and in monsoon climates is a secondary breeding period for some amphibians. Fall surveys may detect migration to dens, leading to concentrations of reptiles that can be inventoried in small areas.

Given the funding limitations of this program, and the goal of documenting at least 90% of species suspected to be in each park, we will concentrate efforts in groups of parks each year, surveying at different seasons to maximize the chances of finding species. When deemed necessary, additional, intensive surveys may be conducted to try to detect particular species strongly suspected to occur, but that have not been detected in previous efforts. Surveys will be conducted by teams of qualified herpetologists and will follow the progression of seasons, from southern to northern parks, and from low elevations to higher elevations.

Fish Methods

General inventories for fish are not being proposed as part of this project, therefore we are not detailing methods here. However, three unfunded special fish inventory projects have been identified and are described in Appendix F.

Vascular Plant Methods

Vegetation Classification. An important step in all taxonomic group studies will be to classify and describe the vegetation and site features of the sampling locations. Overall future data comparisons and interpretation will be facilitated by a consistent approach. The following section provides an overview of our approach to classifying vegetation types associated with this inventory project.

In order to be useful in inventory work, a vegetation classification needs to have some form of hierarchical structure. Currently, three vegetation classifications being used on the Colorado Plateau provide this structure, the Standardized National Vegetation Classification (SNVC), the Brown-Lowe-Pase (BLP) classification (Brown 1982), and the SRFR vegetation classification (Spence et al. 1995, Spence 1997a). The SRFR is a modified BLP classification with some differences in hierarchical structure. There is also relatively close correspondence between the SNVC and SRFR systems for some hierarchical levels. The SNVC is to be used by all government agencies in order to facilitate uniform vegetation classifications and communication between agencies. However, it is an extremely complex system that remains incomplete and requires additional plot data on canopy coverage before vegetation can be classified. In particular, the SNVC levels Physiognomic Group and Formation still have some ambiguity in how new vegetation types need to be classified.

We will use the following approach for vegetation classification as part of the inventory process on the Colorado Plateau:

SRFR (field classification) → SNVC (office and report classification)

While sampling in the field, the vegetation type will be determined using the relatively simple and quick SRFR classification. Estimation in the field of woody plant canopy coverage is needed to convert from SRFR to SNVC. This will be accomplished through the use of a CPVAC releve data form (see below under Field Methods). Once the vegetation is determined, the SRFR field type will then be converted into the analogous SNVC type in the office for report preparation. It is recommended that additional data, specified on the CPVAC form (Rowlands 1994), be collected at each sampling point as well, including data on landforms, elevation, soils, geology, and disturbances.

Since both systems are hierarchical, sampling for flora and vertebrates can be done at any level, from the relatively broad formation type, through intermediate levels (e.g., evergreen forest, montane cold-deciduous shrubland, cold-temperate mixed short bunchgrass-sodgrass grassland), to floristic alliances or associations. Examples of the hierarchical levels for both the SRFR and SNVC can be found in Table 5.

Table 5. A comparison of the relationship between the SRFR vegetation classification and the Standardized National Vegetation Classification (SNVC). The example is for a closed canopy Pinus ponderosa/Festuca arizonica community.

SRFR CLASSIFICATION	EXAMPLE	SNVC CLASSIFICATION	EXAMPLE
Biogeographic Realm	Nearctic	-	-
Floristic Province	Colorado Plateau	-	-
Climate-Elevation Zone	Montane	-	-
-	-	Division	Vegetated
Formation	Forest	Order	Forest
-	-	Physiognomic Class	Closed Canopy
Physiognomic Class	Evergreen	Physiognomic Subclass	Evergreen
-	-	Physiognomic Group	Temperate/Subpolar Needle-leaved
-	-	Subgroup	Natural
-	-	Formation	Rounded Crowns
Alliance	*Pinus ponderosa*	Alliance	*Pinus ponderosa*
Association	*Pipo/Festuca arizonica*	Association	*Pipo/Festuca arizonica*

Study Area Vegetation. A general description of the vegetation of the parks in the NCPN can be found in section III of this plan. An Excel database has been developed with lists of vegetation types for the 16 network parks (Appendix H). The basic type is the SRFR and/or SNVC alliance, which is named by the dominant species or group of species. For example, Ponderosa Pine forest, Pinyon-Juniper woodland, etc. These alliances can be grouped into higher level types in order to simplify sampling for vertebrate groups. Currently, 73 alliances are recognized among the parks in the NCPN, organized into forest and woodland, savanna, shrubland, mat shrubland, grassland, marshland, forbland, barren, and unclassified types. This list is not likely to be complete for all 16 parks. Some of the alliances recognized may not actually be represented by on-the-ground vegetation.

The use of a releve to describe the vegetation at each sampling point will allow for direct comparisons between parks for not only floristic data, but vertebrate survey data as well. In addition, the use of a standard releve size means that species-area curves can be calculated for floristic species richness estimates. Because of the value of doing vegetation description, we will require all inventory teams to use some type of releve form for documenting dominant species, such as the CPVAC form, to describe the vegetation at each sampling point. Our suggested approach is to complete an abbreviated releve (for 5-7 dominant species) which will require less time than a full releve. This data will be sent to the plant ecologist at Glen Canyon NRA for analysis and classification using the SRFR and SNVC classifications. One goal of this is to eventually produce a database of vegetation descriptions for all Colorado Plateau parks at the alliance level.

Vegetation Inventory Techniques. Once a sample point is selected, there are many different ways of sampling the flora and vegetation at the point. These can be divided into two basic categories, area searches, or some form of area or plot sampling. Although different methods are detailed below, some of them are included only because they can be used for long-term monitoring. For basic inventory work, a combination of an area search and one or more releve's will be sufficient. If the releve center is permanently located using GPS, then future monitoring can be done by repeated visits for floristic and vegetation information. The more complex transect and modified-

Whittaker plots are much more time-consuming, and are generally not recommended for general floristic inventories, unless the intent is to establish plots for long-term monitoring. We will use a combination of these methods depending on individual park needs.

Area Searches. The area around the sample point can be thoroughly searched for species presence. As part of the fieldwork amount of time expended and the number of searchers should be noted. The search can be limited to a particular community type, or if the sample point is located in a mosaic of types or on an ecotone, all types and the ecotone should be searched. Experienced botanists are required in order for this technique to be useful. Another problem is that to sample the total flora, several visits may be necessary at different seasons. This is primarily because of different groups of annual species that germinate and flower in spring or after the summer monsoons. In drought years, many annuals will not even germinate. This technique, combined with one or more releves, is the recommended method for completing basic floristic inventories in the parks.

Transects. A method that can be used to collect quantitative data, and that can be used for long-term monitoring, involves establishment of a vegetation transect. A transect is typically either 30 or 100 meters long, and is permanently located. Various kinds of data can be collected along this transect, including cover and frequency data from quadrat frames, line-intercept cover, and height-cover points. Variations on this approach are widely used in monitoring designs, for example Glen Canyon NRA upland vegetation (Spence 1997b) and Channel Islands NP (Halvorson et al. 1988). The transect method is easier and quicker to use than the modified Whittaker plot technique (see below), but cannot easily be used for species-richness estimates by the species-area curve approach.

Plot Sampling. Plot sampling can consist of a randomly placed temporary or permanently positioned plots. Two basic methods in use regionally are suggested below.

The relatively simple CPVAC releve method can be used if detailed quantitative data is not required. In this technique, a circular plot of specified dimensions is positioned in the community of interest, and species presence is recorded within the area. A standard area is 0.1 hectare (circular plot diameter of 17.84 meters). A ranked scale of abundance from 1-5 is assigned to each species. Estimates of canopy cover and vegetation height by strata, and notes on disturbance can also be collected. The method is detailed in Rowlands (1994). If this releve is permanently fixed using GPS, then it can be incorporated into future monitoring work. Estimates of amount of time for this technique vary from ca. 20-40 minutes/releve depending on vegetation complexity and experience of the field crew.

A more detailed and useful method is based on a modified Whittaker plot design. Although much more time-consuming than the other methods, a great deal of useful data can be collected for subsequent analysis, and the plot can also be used as a permanent monitoring location. A modified-Whittaker plot is a rectangle 20 meters by 50 meters (1000 m^2 or 0.1 hectare). Various smaller plots, ranging from 1 m^2 to 100 m^2 are positioned within the macroplot. Within each of these smaller plots species presence, and if necessary canopy cover or density, is determined. When a variety of these macoplots are sampled, species-area curves can be directly constructed using a range of nested plot sizes. Examples of this method can be found in Stohlgren et al. (1995) and Yorks and Dabydeen (1998).

VII. DATA MANAGEMENT AND VOUCHER SPECIMENS

DATA MANAGEMENT

The Northern Colorado Plateau Network views data management as central to the success of a network inventory and monitoring program. The ultimate value of these inventories is in the information that they generate, and it is essential that this information be easily accessible to park managers and others in order to make informed decisions on resource management within the parks. Therefore we are placing a high priority on developing an integrated network data management system to ensure that biological inventory and monitoring data are organized and managed in formats that are most useful to park managers. We will emphasize the use of GIS spatial datasets and tools which offer friendly user interface options (e.g., GIS databrowser; web access).

Another important aspect of data management will be to create an approach that will endure beyond the funding cycle for this initiative. With the frequent turnover in park resource personnel it is imperative that we are successful in developing data management protocols which ensure the long-term integrity and accessibility of these datasets. We cannot afford to continually reinvent the wheel. Our experience this year in assembling existing inventory data has been a strong reminder of the large amount of effort required to obtain and manage data and the importance of going through this exercise only once. Park resource staffs are much more mobile now than in former years and as a result institutional knowledge of park resources is often lacking. A well organized data management system can help fill the void of longer-tenured resource staff and can offer a very useful tool in acquainting new staff with all the previous work conducted within a park.

Network Coordination and Data Management. As detailed in project statement ALLTAX-01 in Appendix E, the network intends to staff a five-person team for overall project coordination and data management. A full-time network program coordinator is already in place. This fall the network will hire a permanent full-time data manager to oversee development of the data management aspects of the I&M program. We will rely on this new person to help us develop a network wide strategy for data management. We envision a data management system which is largely centralized at the network I&M project office in Moab. However, we anticipate that there will also be decentralized components to data management, in that several parks already have existing GIS and data management staff. The network data management plan will address how to most efficiently and effectively accomplish data management goals capitalizing on the resources available. A close partnership will be developed and maintained with the Southern Colorado Plateau Network program to ensure consistency in form and quality of data. We will also work closely with other outside partners where data compatibility and sharing is desired.

Emphasis on Existing Data. The network realizes that a great wealth of park inventory information lies in datasets, reports and other formats which are not readily accessible. We are placing a high priority on the identification of all existing inventory data for each park. Individual project statements in Appendix E address the need for obtaining and assessing existing information. For each inventory dataset we will access the quality and usefulness of the existing information. All pertinent reports and datasets will be referenced in the Dataset Catalog (metadata) and/or NRBibliography. Metadata standards will meet Federal Geographic Data Committee (FGDC) requirements.

Existing data will come in a variety of tabular and spatial formats. As recommended by the national I&M program we will use Microsoft Access for organizing tabular data and all GIS products developed will be compatible with ArcView software. We anticipate developing a centralized network Access database and/or data standards for inventory data. A centralized network database can be made available to all parks through web-based developments.

In addition to network-based databases, we will also continue to update data in the suite of national I&M databases including: NPSpecies, NRBib and Dataset Catalog. Section IV of this study plan documents the work we have accomplished so far with these databases. New inventory information will be generated annually through field investigations. We will establish protocols for updating these databases, as well as the network inventory databases regularly.

VOUCHER SPECIMENS AND CURATION

For documenting species occurrences, vouchers represent the most concrete evidence available. Vouchers may be an actual specimen (collected and preserved) or a photograph. All voucher specimens will be georeferenced. The network is actively gathering information, from a variety of sources, on existing specimen vouchers for park species. To date we have not had the opportunity to review voucher photographic resources in each of the parks. This work will be completed as part of conducting the basic inventory work starting in FY01.

As part of the upcoming field inventory effort, we will augment existing voucher material so that almost all vascular plant and vertebrate species within a park (except listed threatened and endangered taxa) are represented by voucher specimens or photographs. Collection of specimens will follow policies outlined in NPS Management Policies, Museum Objects and Library Materials (5:9-11); Security and Protective Measures (5:12-13); Preservation of Data and Collections and Protection of Research Potential (5:3-4) Chapter 5 and NPS 77, the Natural Resource Management Guideline.

In order for collections to be of the greatest utility to the broader scientific community, as well as individual parks, we will consider deposition of specimens in larger accredited regional collections, especially ones that currently serve as major repositories for NCPN park specimens. When the primary depository is a park collection, specimen information is often not readily accessible for broader use. Specimen deposition will be considered on a taxonomic group basis. Voucher photographs will be deposited in individual park archives.

Following are taxonomic group specific guidelines and thoughts on obtaining vouchers. For many parks and many taxonomic groups significant voucher resources already exist. In field investigations, we will emphasize obtaining voucher information for presently unvouchered park species. All voucher data will be cataloged in ANCS+ and NPSpecies databases. Voucher specimens will not be collected for listed threatened and endangered species, unless specifically approved by US Fish and Wildlife Service.

Bird Vouchers. In general, bird specimens for NCPN parks are poorly represented within internal (NPS) and external museum collections. Bird voucher specimens will not be collected as part of this inventory effort, except in cases where animals are found dead and in identifiable condition. Instead, to the degree possible we will ask field investigators to acquire voucher photographs. We realize that photographing birds is often not feasible, and that many birds are identified by sound rather than sight. Bird vouchers may be deposited in park collections or larger institutional museums such as Northern Arizona University, Museum of Northern Arizona, Brigham Young University, or Utah State University.

Mammal Vouchers. Some NCP parks are the beneficiaries of previous surveys in which mammal voucher specimens have been taken and deposited in accredited museum collections. In particular, the USGS Biological Survey Collection in the Museum of Southwestern Biology, University of New Mexico, Albuquerque, has significant holdings of mammals, and some amphibians and reptiles, from NCPN parks. For parks, which are not scheduled for additional inventory work, we will rely on existing vouchers for documentation (e.g., for NPSpecies) rather than take additional vouchers. There are few significant taxonomic problems for mammals on the plateau that require additional vouchers but these should be taken by principal investigators as approved for research, rather than as part of an inventory or monitoring effort.

However, there should be no mistake that voucher specimens, identified to the extent possible, properly cataloged and accessioned, and deposited in accredited museums are fundamental to an improved understanding of occurrence and distribution of vertebrate species and plants on NCPN parks. All new mammal inventory work on NCPN parks should be properly vouchered. For species where it is not appropriate (e.g., protected species) or feasible (e.g., black bear or pronghorn) to take voucher specimens, documentation should be provided in some other form. We will attempt to document such species with voucher photographs of individuals, their sign, or scat. For parks with little or no previous inventory work, we will retain small numbers of all species for which voucher specimens can be prepared. We will salvage dead animals whenever possible (e.g., road-killed animals) and will work with each park to process material they may have in freezers on-site.

Museums that currently have holdings of mammals from the NCP include University of Colorado Museum, Boulder; University of Wyoming (inactive), Laramie; University of Kansas, Lawrence; Carnegie Museum, Pittsburgh; Utah Museum of Natural History, Salt Lake; and Biological Survey Collection, Museum of Southwestern Biology, Albuquerque. For mammals we recommend deposition in the Museum of Southwestern Biology; variances to this can be resolved as needed.

Reptile and Amphibian Vouchers. At a minimum, presence of reptile and amphibian species at each park should be documented using high-quality photographs (close-up color slides). Animals found dead and in identifiable condition should also be salvaged as voucher specimens (e.g., those found dead on the road). Depending on park needs, live animals may also be collected and preserved as voucher specimens. This is particularly important when species are found at parks that are not expected, and/or range extensions.

A potential negative side effect of any wildlife research project is injuring or stressing captured animals. Researchers may minimize stress by releasing animals as quickly as possible after capture. There is no reason to mark animals as part of the initial inventory work, but marking is more critical to the success of the future monitoring phase of the I&M projects. All animals captured during monitoring should be marked to assist with detection of long-term population trends, and to assess relative abundance and distribution of local reptiles and amphibians. Lizards may be toe-clipped (Ferner 1979); snakes may be scale-clipped (Ferner 1979); and amphibians may be freeze-branded (Donnelly et al. 1994). All of these methods will produce a mark that will be identifiable over at least several years, and none are thought to cause severe pain or long-term suffering to the animals. All procedures for handling the animals will be reviewed and approved by a University Institutional Animal Care and Use Committee (IACUC), and by each state's Game and Fish Department.

Vascular Plant Vouchers. *Voucher specimens will be collected for all new vascular plant species (except listed threatened and endangered) encountered during surveys. At least one specimen of each species collected will be deposited in each park that has a herbarium. Duplicate specimens and specimens for parks that lack a herbarium will be deposited in a major regional herbarium, such as one of those at Utah State University, Brigham Young University, University of Colorado or University of Wyoming.*

VIII. BUDGET AND SCHEDULE

The NCPN has developed the following budget and schedule to accomplish inventory work under the present funding initiative. A total of $1,037,439 has been identified for the inventory phase of the NCPN I&M program. We received $123,000 of this funding in FY 2000 to develop this study plan and initiate inventory work. Through this study plan we are requesting the remaining funding of $914,439, to be distributed to inventory work in the network over a four-year period.

Work conducted in FY 2001. The NCPN received $123,000 to complete work described in the network pre-proposal (NPS 1999b). Specifically the NCPN hired a full-time project manager and seasonal biotechs to develop the study plan and conduct the NPSpecies and other database work. Funding was also utilized to host a 3-day experts workshop in late May. Additionally we contracted with subject matter experts for assistance in developing various components of the study plan and for help with compilation of master vertebrate and vascular plant species lists. After these expenditures the NCPN had a residual balance of $13,000 from FY 2000 funding. Through an interagency agreement with the USGS, these funds have been allocated for mammal inventory work next field season.

Work proposed for completion in FY 2002-2004. The two tables below summarize the budget and time schedule for NPCN inventory work by taxonomic groups and individual inventory projects. Detailed project budgets and implementation schedules are found in the individual project statements in Appendix E. These statements also describe our approach to project implementation. We anticipate significant involvement of USGS, Biological Resource Division scientists as well as partners of the Colorado Plateau Cooperative Ecosystem Studies Unit (CESU). Interested and qualified investigators will be sought through requests for interest and qualification. In addition, some of the inventory work will be contracted out through other sources.

Since the NCPN has been selected for initiation of a network monitoring program in FY 2001, we have requested a larger proportion of our inventory funding be distributed early on in the project. Our rationale is that we would like to expedite completion of general inventories to provide a stronger foundation for development of the monitoring phase of the program.

We are allocating approximately 20% of overall inventory funding to coordination and data management (see project statement ALLTAX-01 in Appendix E).

Summary of inventory funding by taxonomic groups.

PROJECT	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	TOTAL
Project Initiation and Study Plan	110,000					110,000
Coord./Data		115,034	50,270	28,076	24,526	217,906
Birds		43,224	60,420	37,172	18,053	158,869
Mammals	13,000	44,000	57,000	43,000	43,000	200,000
Herps		60,619	60,619	40,614	40,614	202,466
Plants		21,266	64,466	49,466		135,198
Cave		6,500	6,500			13,000
	123,000	290,643	299,275	198,328	126,193	1,037,439

Summary of inventory funding by individual projects.

PROJECT	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	TOTAL
ALLTAX – 01 Project Coordination & Data Mgt.		105,034	50,270	28,076	24,526	207,906
ALLTAX-02 Network Sensitive Species Project		10,000				10,000
CAVE-01 Timpanogos Cave Inventory		6,500	6,500			13,000
BIRDS-01 Small Parks General Bird Inventory		43,224	41,060			84,284
BIRDS-02 BLCA/CURE General Bird Inventory			19,360	18,343		37,703
BIRDS-03 SW Willow Flycatcher/YB Cuckoo				18,829	18,053	36,882
MAMMALS – 01 Baseline Mammal Inventory	13,000	37,000	50,000			100,000
MAMMALS – 02 Focused Mammal Inventory		7,000	7,000	43,000	43,000	100,000
HERPS-01 General Herp Inventory – All Parks		60,619	60,619	40,614	40,614	202,466
PLANTS-01 Herbarium Search		10,000	10,000			20,000
PLANTS-02 Hovenweep Floristic Inventory		4,766	4,466	4,466		13,698
PLANTS-03 Timpanogos Floristic Inventory		5,000	5,000			10,000
PLANTS-04 Black Canyon/Curecanti Plants			20,000	20,000		40,000
PLANTS-05 Plant Inventory Dinosaur NM			25,000	25,000		50,000
PLANTS-08 Fossil Butte Sensitive Plants		1,500				1,500

Total Funding Requested from I&M Program (FY2002-2004) $914,439

IX. PRODUCTS AND DELIVERABLES

Annual reports summarizing progress of inventories will be prepared and provided to network parks, the Regional I&M Coordinator and National Servicewide I&M Coordinator. At appropriate intervals, copies of all products will be also be distributed to these same entities. At the completion of each inventory we will provide:

a. Description of the protocol
b. Inventory data in MS Access with appropriate documentation
c. GIS data
d. Metadata for new datasets utilizing FGDC standards.
e. Updates to NPSpecies database.
f. Updates to NRBib database.

X. COORDINATION AND LOGISTICAL SUPPORT

The nine-member Northern Colorado Plateau Network Steering Committee has overall responsibility for the network inventory and monitoring program. The network I&M program manager and associated staff work to implement the program as directed by the steering committee. Periodic meetings between the steering committee and program staff ensure that all key decisions and program needs are addressed in a timely manner. Regular communication between the program manager and steering committee ensures a smoothly functioning program.

Network parks and I&M project staff will assist with logistical support needed to complete field inventories. Appendix I provides a summary of individual park resources that may be available to this project, including housing, camping, office space and vehicle use. Unfortunately many parks have little to offer in the way of facilities. The network will support logistical needs of cooperators and project staff as much as possible.

As mentioned elsewhere in this study plan, the network will attempt to coordinate inventory work in close cooperation with the Southern Colorado Plateau Network. Taxonomic group methodologies identified in this plan are proposed for use across both networks. Additionally, we will attempt to identify and employ comparable data management protocols so that data may be shared plateau wide.

XI. ACKNOWLEDGEMENTS

Many people have contributed to the completion of this study plan. Network I&M Program Manager, Dr. Angela Evenden had overall responsibility for development and coordination of the study plan, and for writing many sections. Several USGS scientists (Dr. Mike Bogan, Matt Johnson, Dr. Tim Graham, Erika Nowak, Trevor Persons and David Mattson) and NPS scientist Dr. John Spence contributed to the taxonomic group protocol sections and individual project statements. Northern Colorado Plateau Network Steering Committee Members and park staff (Tom Clark, Charlie Schelz, Ken Stahlnecker, Rick Wallen, Mary Hunnicutt, Denise Louie, Tamara Naumann, Steve Petersburg, Mike Gosse, Bruce Powell, Ellen Mayo and Clayton Kyte) provided park descriptions and inventory summaries found in Appendices A and C, as well as individual project statements. GIS Specialist, Gary Wakefield produced network and park maps for this study plan. Dr. Mark Miller, Ecologist with the Grand Staircase-Escalante National Monument contributed overview information on plant communities. Chris Florian and Elliott Swarthout assisted with editing various portions of this study plan.

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